



# **The Demand for Commodity Insurance by Developing Country Agricultural Producers: Theory and an Application to Cocoa in Ghana**

By

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# Outline of presentation

- *Theoretical framework*
- *Data requirements and adaptation to Ghana*
- *Estimates of Willingness To Pay (WTP) and comparison with actual put option prices*

**Main Question:** How much price insurance for the commodities produced would agricultural households in a developing country wish to obtain, and how much would they be willing to pay for it?

Equivalently, what is the welfare benefit of price insurance?

**Second question.** Can the demand for commodity price insurance be covered by put options in organised exchanges?

*Context.*

- Existence of covariate commodity price (and other) risks induces rural households to adopt consumption smoothing strategies. Still considerable residual consumption risk.
- Willingness to pay (WTP) for commodity price insurance must be assessed in the context of existing insurance systems.
- WTP must be assessed in the context of an overall insurance strategy. Not a one shot affair.

# Methodologies to assess welfare benefits or WTP for farm insurance

- *Direct questioning of producers, related to the literature on contingent valuation (**CV method**).*
- *Use of theory along with the combination of microeconomic household information, and market information to estimate indirectly the appropriate premiums (**indirect method**).*
- *Inference of the willingness to pay from analysis of the patterns of production and other behavior of producers (**revealed preference method**).*

# Theory

- *The theory outlined pertains to the case of insurance offered within one crop year, and after the major short term production decisions, such as land and fertilizer allocations, have been made.*
- *It assumes that the long term diversification pattern of the producer stays unaffected.*
- *In this sense, the estimated benefit, and WTP can be considered as the minimum demand for price insurance.*
- *Any changes in production structure will provide an additional benefit, but will not be considered here.*

# A model for the demand for commodity price insurance

- The household will be postulated to maximize the ex-ante expected value of the discounted sum of instantaneous utilities, over  $n$  crop years.

- (1) 
$$W = E\left\{\sum_{t=1}^{2n} \delta^t U(C_t)\right\} / I_1$$

where  $\delta$  denotes an appropriate discount factor.

- The restrictions relating the various variables are the following.

- (2) 
$$p_{At} A_{t+1} = p_{At} A_t + p_t y_j(A_t, x_t, S_t) - p_{Ct} C_t \equiv R_t - p_{Ct} C_t$$

- (3) 
$$x_t \in X_t$$

- Solution is of form:

- (4) 
$$C_t = f(I_t) = f(A_t, y_j(A_t, S_t), p_t, p_{At}, p_{Ct})$$

# Implicit definition of WTP

If an equation like (4) is the solution to the overall optimization problem (1)-(3), then the utility function in (1) can be rewritten as follows.

$$(5) \quad W = E \left\{ \left\{ \sum_{T=0}^n \delta^{2T} \left[ U(C_{2T+1}) + \delta E(C_{2T+2} | I_{2T+1}) \right] \right\} \middle| I_0 \right\} \equiv E \left\{ \sum_{T=0}^n \delta_1^T V(C_{2T+1}, I_{2T+1}) \middle| I_0 \right\}$$

The benefit from insurance of amount  $q$  that pays  $r$  per unit, in year  $T$  is the solution  $B$  to the following implicit equation.

$$(6) \quad U(C_{2T+1}(y_1 - B)) + \delta E \left[ U(C_{2T+2}(y_2 + rq)) \middle| I_{2T+1} \right] = U(C_{2T+1}(y_1)) + \delta E \left[ U(C_{2T+2}(y_2)) \middle| I_{2T+1} \right]$$

We approximate (4) by the following aggregate consumption function.

$$(7) \quad \hat{C}_t = C_t^* + \beta \frac{(R_t - R_t^*)}{P_{Ct}} = C_t^* + \beta(R_t - R_t^*)$$

Denote by  $z$  the term that include the total (real) return to the insurance contract:

$$(8) \quad z = rq$$

whereby  $r$  we now denote the return to the insurance contact.

Expression for the benefit or WTP for commodity insurance (after substitution, Taylor series expansion to second order, and normalization)

***WTP for price insurance next period conditional on current period prices***

(9)

$$B^r = \delta E(z^r) + \frac{1}{2} \theta \left[ (\Delta R_1^r)^2 - \delta \{ E(z^r)^2 + 2E(z^r \Delta R_2^r) \} \right]$$

where

(10)

$$\theta = \rho \beta$$

Actuarially fair premium if  $\theta = 0$

$$(11) \quad B_0^r = \delta E(z^r) = \delta E(r^r q^r)$$

$B^r$  Depends on current state of nature

## Unconditional expectation of (11) gives average value of WTP

- ***WTP for price insurance***

$$(12) \quad \bar{B}^r = E_{y_1} \left\{ \delta E(z^r | y_1) + \frac{1}{2} \theta \left[ (\Delta R_1^r)^2 - \delta \left\{ E(z^r | y_1)^2 + 2E(z^r \Delta R_2^r | y_1) \right\} \right] \right\}$$

# Conclusions from theory compatible with intuition

- *The larger is the degree of risk aversion (larger value of  $\rho$ ), and the smaller is the degree of consumption smoothing (larger values of  $\beta$ ), the larger is the benefit of insurance.*
- *The larger is the degree of (unpredictable) deviation of current resources from normal (positive or negative), the larger is the WTP for insurance.*
- *The larger is the variance of the return of the insurance contract, the lower the WTP for it.*
- *The WTP for an insurance contract is larger with a more negative correlation between the return to insurance and the second period resource uncertainty.*

# Empirical implementation of the model

- Need to be specified empirically, apart from the parameters  $\beta$  and  $\rho$ , the following expressions.
- The first three of these expressions are the expectations with respect to the conditioning variables, of the one period ahead conditional expectations. If the conditional expectations do not depend on any first period variables, then the unconditional and the conditional expectations are the same. The last term is an unconditional variance

$$E(r^r q^r)$$

$$Var(r^r q^r)$$

$$Cov(r^r q^r, R_2^r)$$

$$Var(\Delta R_1^r)$$

# *Assumptions made in empirical specification*

- Assumption is made that the return to the price insurance contract is independent from the quantity insured.
- To simplify, it is assumed that the price of the insured crop is independent of the domestic prices of all other agricultural products, as well as the quantities produced.
- Assume furthermore that the insurance contract covers a share  $\gamma$  of the produced crop. If  $\gamma=1$ , then all production is insured, irrespective of outcome.
- Specify models of domestic price formation that assume partial *international tradability* of the various products, as follows.

# Price Equations

International price equations

$$\Delta \ln p_t = \alpha_0 + \alpha_1 t + \beta_1 \Delta \ln p_{t-1} + \beta_2 \ln p_{t-2} + \sum_{k=1}^{11} \gamma_k \text{month}_k + \varepsilon_t$$

**Domestic price equations**

$$\log p_{it}^r = \alpha_i + \zeta_i \log p_{it}^{rw} + \eta_i \log y_{it}^r$$

$$\Delta \ln p_t = \alpha_0 + \alpha_1 t + \beta_1 \Delta \ln p_{t-1} + \beta_2 \ln p_{t-2} + \zeta_0 \Delta \ln p_t^w + \zeta_1 \Delta \ln p_{t-1}^w + \zeta_2 \Delta \ln p_{t-2}^w + \eta \Delta \ln PROD_t + \sum_{k=1}^{11} \gamma_k \text{month}_k + \varepsilon_t$$

**Table 1: Structure of income of cocoa producing households in the rural forest region of Ghana**

	Share of cocoa in household income											
	0-20%				20-40%				>40%			
	Share of agriculture in household income				Share of agriculture in household income				Share of agriculture in household income			
	<60%		>60%		<60%		>60%		<60%		>60%	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
<b>Estimated number of households in Ghana</b>	18668	50048	47133	106948	3983	11068	23540	64912	979	2855	23017	58395
<b>Share of total households (%)</b>	0.42	1.12	1.05	2.39	0.09	0.25	0.53	1.45	0.02	0.06	0.51	1.31
<b>Share of total income from</b>	(Percent)											
<b>Cocoa</b>	6.8	6.1	8.6	8.9	26.4	26.1	31.7	28.6	42.2	46.9	53.5	56.6
<b>Cereals</b>	2.2	1.3	5.3	3.0	0.1	1.5	3.5	2.0	0.0	0.0	1.6	1.8
<b>Other Cash Crops</b>	0.3	1.5	0.5	0.5	0.0	0.0	0.9	0.1	0.0	0.0	0.1	0.1
<b>Roots</b>	2.8	3.2	18.4	14.4	0.4	0.1	5.3	11.0	0.0	0.0	1.9	2.5
<b>Fruits</b>	0.5	0.9	8.6	10.8	0.7	0.3	3.2	4.0	0.0	0.0	1.8	0.5
<b>Vegetables</b>	0.1	1.1	7.1	4.3	0.6	1.7	2.1	2.0	0.0	0.0	0.7	0.6
<b>Processed Crops</b>	4.5	1.2	11.6	10.6	2.2	0.0	3.4	5.4	0.0	0.0	6.8	3.4
<b>Other Agriculture</b>	0.1	0.2	1.8	0.9	0.1	0.3	2.7	0.3	0.0	0.2	0.3	0.5
<b>Consumption of own Production</b>	23.7	14.6	28.8	34.6	14.2	14.1	37.6	37.2	9.4	8.5	23.1	26.3
<b>All agriculture</b>	41.0	30.1	90.6	87.9	44.7	44.1	90.3	90.6	51.5	55.6	89.7	92.3

**Table 2. Coefficients of variation and correlation matrix of domestic production yields  
(only significant correlations at 10% or better are shown)**

		Correlation matrix						
	Coefficient of variation	Cocoa	Maize	Groundnuts	Cassava	Plantain	Onions	Consumption of own Production
Cocoa	0.20	1.00						
Maize	0.18	0.45	1.00					
Groundnuts	0.23	-0.29		1.00				
Cassava	0.13		0.50	-0.57	1.00			
Plantain	0.12	0.37	0.56		0.44	1.00		
Onions	0.17		-0.28		-0.52	-0.36	1.00	
Consumption of own Production	0.13		0.61	-0.54	0.99	0.49	-0.52	1

**Table 3: Results of time series regressions for world monthly prices of products relevant to Ghana**  
**(Dependent variable is  $\Delta \ln x_t$  where  $x_t$  is the deflated world monthly price of the reported commodity)**

Independent variable	Cocoa		Maize		Banana		Groundnuts	
	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic
Constant	0.0345*	1.777	0.0336**	2.142	0.6633***	5.998	0.1175***	2.95
Linear trend	-0.0001**	-1.991	-0.0002**	-2.115	-0.0008***	-3.73	-0.0001**	-2.229
$\Delta \ln x_{t-1}$	0.1560***	3.045	0.2960***	4.636	-0.4703***	-6.923	0.3549***	5.681
$\ln x_{t-2}$	-0.0181**	-2.199	-0.0484***	-2.805	-0.3656***	-6	-0.0480***	-3.093
January	0.0194	1.162	-0.0003	-0.019	0.1179**	2.231	-0.002	-0.115
February	-0.0187	-1.12	-0.0167	-1.032	0.1926***	3.578	-0.0141	-0.815
March	0.0101	0.609	0.0158	0.991	0.0768	1.394	0.0058	0.341
April	-0.0169	-1.01	-0.0182	-1.125	0.0611	1.08	0.019	1.1
May	-0.0059	-0.353	-0.0048	-0.295	-0.0254	-0.451	0.0077	0.444
June	-0.0094	-0.564	-0.0066	-0.405	-0.052	-0.934	0.0068	0.392
July	0.0132	0.792	-0.0378**	-2.331	-0.0372	-0.686	-0.001	-0.059
August	-0.0096	-0.577	-0.026	-1.587	-0.0274	-0.511	0.0158	0.916
September	0.0111	0.668	-0.0236	-1.441	0.002	0.038	-0.0254	-1.464
October	-0.0184	-1.101	0.0046	0.279	-0.1292**	-2.43	0.0079	0.453
November	0.0019	0.112	-0.0014	-0.084	-0.044	-0.82	0.0043	0.246
Adjusted R-squared	0.0344		0.1686		0.3055		0.1719	
S.E. of regression	0.0667		0.0498		0.1627		0.0533	

One asterisk denotes significance at the 10 % level, two asterisks denote significance at 5%, and three asterisks denote significance at 1%.

**Table 4: Results of time series regressions for domestic monthly prices of products relevant to Ghana (Dependent variable is  $\Delta \ln x_t$  where  $x_t$  is the deflated domestic monthly national wholesale price of the reported commodity. Estimation period is 1970-1999)**

	Maize		Groundnut		Plantain		Cassava		Onions	
	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic
<b>Constant</b>	0.7028*	1.873	0.9172***	2.604	0.6835	0.88	2.7962**	2.307	2.3876***	6.55
<b>Linear trend</b>	-0.0003*	-1.918	-0.0003***	-3.672	0.0002	1.075	0.0001	0.107	-0.0007***	-4.705
<b>LnX(t-2)</b>	-0.1152***	-4.174	-0.1784***	-4.91	-0.2894***	-6.204	-0.2402***	-6.018	-0.3355***	-7.742
<b>LnX(t-1)</b>	-0.2404***	-4.48	-0.4653***	-8.95	-0.5328***	-10.007	-0.3894***	-7.259	-0.2918***	-5.393
<b>LnPRODX(t)</b>	-0.0004	-0.014	0.0248	1.046	0.0132	0.234	-0.1113	-1.331	0.0018	0.092
<b>January</b>	0.0918**	2.438	0.0501	1.61	0.0051	0.089	0.1714**	2.149	-0.2014***	-4.208
<b>February</b>	0.0691*	1.862	0.0834***	2.668	-0.0415	-0.724	0.083	1.03	-0.1985***	-4.015
<b>March</b>	0.0416	1.122	0.0575**	1.85	-0.0507	-0.881	-0.0534	-0.674	-0.2948***	-5.996
<b>April</b>	0.1103***	2.955	0.0507	1.633	-0.0965*	-1.67	0.0936	1.186	-0.2015***	-3.92
<b>May</b>	0.1013***	2.722	0.0607**	1.958	0.3337***	5.725	0.0397	0.5	-0.1185**	-2.289
<b>June</b>	0.0608	1.613	0.0439	1.403	0.2677***	4.408	-0.0412	-0.521	-0.0678	-1.323
<b>July</b>	-0.0437	-1.144	0.0770**	2.463	0.2094***	3.603	-0.042	-0.532	0.015	0.299
<b>August</b>	-0.2158***	-5.53	0.0401	1.273	0.1002*	1.707	0.0248	0.315	-0.0112	-0.23
<b>September</b>	-0.1935***	-4.71	-0.0832***	-2.643	0.0102	0.174	0.0084	0.106	-0.0201	-0.422
<b>October</b>	0.0397	1.005	-0.0589**	-1.855	-0.0567	-0.977	0.0657	0.825	-0.0267	-0.564
<b>November</b>	0.1168***	3.172	-0.0188	-0.604	-0.0091	-0.158	-0.0663	-0.83	0.0257	0.544
Adjusted R <sup>2</sup>	0.3708		0.2548		0.379829		0.1686		0.3273	
S.E. of regression	0.142		0.1185		0.218147		0.3025		0.1828	

One asterisk denotes significance at the 10 % level, two asterisks denote significance at 5%, and three asterisks denote significance at 1%.

**Table 5: Coefficients of variation and correlation matrix of domestic real prices**

	Coefficient of variation	Maize	Cassava	Groundnut	Plantain	Onion
Maize	0.142	1				
Cassava	0.303	0.097	1			
Groundnut	0.118	0.094		1		
Plantain	0.218				1	
Onion	0.183	0.121		0.088		1

**Table 6: Comparison of actual put option prices and actuarially fair insurance premiums**

**from model for three months ahead. (All prices expressed as shares of future prices)**

Futures price (\$/mt)	Strike price (\$/mt)	Strike Price Relative to futures price (% deviation from future price)	Put option price as share of futures price	Model computed actuarially fair insurance price (% of futures price)	Difference Actual put option-Model (% of futures price)	Difference Actual put option-Model (% of actual put option price)
<b>Cocoa put option prices NYBOT June 5, 2002</b>						
<b>Three months ahead (September 2002)</b>						
1552	1450	-6.51	2.58	2.52	0.06	2.34
	1500	-3.32	3.8	3.64	0.16	4.27
	1550	-0.13	5.15	5.07	0.09	1.73
	1600	3.07	7.22	6.81	0.41	5.68
	1650	6.26	9.34	8.85	0.49	5.23
	1700	9.45	11.73	11.18	0.55	4.65
<b>Cocoa option prices NYBOT Feb 2, 2001</b>						
<b>Three months ahead (May 2001)</b>						
1058	950	-10.21	2.65	1.56	1.08	40.98
	1000	-5.48	4.44	2.85	1.59	35.9
	1050	-0.76	6.81	4.76	2.05	30.05
	1100	3.97	9.83	7.36	2.47	25.16
	1150	8.7	13.04	10.61	2.44	18.68
	1200	13.42	16.82	14.41	2.42	14.37
<b>Cocoa option prices NYBOT April 4, 2000</b>						
<b>Three months ahead (July 2000)</b>						
838	700	-16.47	0.95	0.61	0.35	36.14
	750	-10.5	2.03	1.5	0.53	26.04
	800	-4.53	4.18	3.18	1	23.92
	850	1.43	7.28	5.88	1.4	19.26
	900	7.4	11.58	9.66	1.92	16.59
	950	13.37	16.23	14.36	1.87	11.53

**Table 7: Comparison of actual put option prices and actuarially fair insurance premiums from model for two and five months ahead**

Futures price (\$/mt)	Strike price (\$/mt)	Strike Price Relative to futures price	Put option price as share of futures price	Model computed actuarially fair insurance price (% of futures price)	Difference Actual put option-Model (% of futures price)	Difference Actual put option-Model (% of actual put option price)
<b>Cocoa option prices NYBOT July 5, 2000</b>						
<b>Two months ahead (September 2000)</b>						
841	750	-10.82	0.59	0.76	-0.17	-28.45
	800	-4.88	1.9	2.1	-0.2	-10.38
	850	1.07	5.11	4.64	0.47	9.24
	900	7.02	9.16	8.51	0.64	7.01
	950	12.96	14.27	13.46	0.81	5.66
	1000	18.91	19.74	19.04	0.7	3.56
<b>Five months ahead (December 2000)</b>						
878	750	-14.58	2.05	1.77	0.28	13.68
	800	-8.88	4.1	3.15	0.95	23.14
	850	-3.19	6.83	5.2	1.63	23.91
	900	2.51	10.25	8	2.25	21.94
	950	8.2	14.01	11.56	2.45	17.48
	1000	13.9	18.45	15.8	2.65	14.37
<b>Cocoa option prices NYBOT July 2, 1999</b>						
<b>Two months ahead (September 1999)</b>						
1048	950	-9.35	1.34	1	0.33	24.97
	1000	-4.58	2.39	2.2	0.19	7.98
	1050	0.19	4.77	4.18	0.59	12.41
	1100	4.96	7.82	7.03	0.79	10.1
	1150	9.73	11.55	10.67	0.88	7.6
	1200	14.5	15.55	14.87	0.69	4.43
<b>Five months ahead (December,1999)</b>						
1084	950	-12.36	3.04	2.24	0.81	26.54
	1000	-7.75	4.52	3.5	1.02	22.51
	1050	-3.14	6.46	5.22	1.24	19.13
	1100	1.48	8.76	7.44	1.33	15.13
	1150	6.09	11.9	10.16	1.75	14.67
	1200	10.7	15.41	13.34	2.06	13.38

**Table 8: Coefficient of variation of income of Ghanaian cocoa producing households due to agricultural uncertainties (percent of average total income)**

Share of cocoa in household income											
0-20%				20-40%				>40%			
Share of agriculture in household income				Share of agriculture in household income				Share of agriculture in household income			
<60%		>60%		<60%		>60%		<60%		>60%	
Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Rural forest											
4.9	3.7	10.1	9.7	12	12	15.7	14.9	19	21.1	24.4	25.8
Other rural											
5.6	3.7	9.4	9.7	NA	15.8	18.4	13.6	19.2	NA	28	22.7
Urban											
4	1.2	13	13.1	13.4	10.7	14.4	12.4	NA	NA	31.5	27.4
Note. A NA for a group means that there no households in the relevant class											

**Table 9: WTP (as share of cocoa income) of Ghanaian cocoa producing households in rural forest region for cocoa price insurance at various levels**

	Share of cocoa in household income											
	0-20%				20-40%				>40%			
	Share of agriculture in household income				Share of agriculture in household income				Share of agriculture in household income			
	<60%		>60%		<60%		>60%		<60%		>60%	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
Number of households	18668	50048	47133	106948	3983	11068	23540	64912	979	2855	23017	58395
Share of total income from cocoa (%)	6.8	6.1	8.6	8.9	26.4	26.1	31.7	28.6	42.2	46.8	53.5	56.6
<b>Strike price relative to future expected price (%)</b>	<b>WTP (share of cocoa income) for price insurance for a fixed 100 of average production with <math>\theta=0.2</math> and 6 months in advance</b>											
10	13.5	13.3	14.6	14.5	13.8	13.8	14.1	14.1	14.3	14.4	14.7	14.8
5	10.3	10.1	11.4	11.2	10.6	10.6	10.9	10.9	11.1	11.2	11.4	11.5
0	7.6	7.4	8.7	8.5	7.9	7.9	8.2	8.2	8.3	8.5	8.7	8.8
-5	5.4	5.2	6.5	6.4	5.7	5.7	6	6	6.1	6.3	6.5	6.6
-10	3.8	3.6	4.9	4.7	4	4	4.3	4.4	4.5	4.6	4.8	4.9
	<b>WTP (share of cocoa income) for price insurance for a fixed 100 of average production with <math>\theta=0.2</math> and 12 months in advance</b>											
10	15.4	15.2	16.5	16.3	15.8	15.8	16.1	16.1	16.2	16.4	16.6	16.7
5	12.5	12.3	13.6	13.4	12.8	12.8	13.1	13.1	13.3	13.4	13.7	13.8
0	9.9	9.7	11	10.8	10.2	10.2	10.5	10.5	10.7	10.8	11.1	11.2
-5	7.7	7.5	8.8	8.6	8	8	8.3	8.3	8.5	8.6	8.8	8.9
-10	5.9	5.7	7	6.8	6.2	6.2	6.5	6.5	6.6	6.8	7	7.1

**Table 10: WTP (as share of cocoa income) of Ghanaian cocoa producing households in rural forest region for cocoa price insurance at various levels**

	Share of cocoa in household income											
	0-20%				20-40%				>40%			
	Share of agriculture in household income				Share of agriculture in household income				Share of agriculture in household income			
	<60%		>60%		<60%		>60%		<60%		>60%	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
<b>Strike price relative to future expected price (%)</b>	<b>WTP (share of cocoa income) for price insurance for a fixed 100 of average production with theta=1 and 6 months in advance</b>											
10	15.5	14.6	21.1	20.2	17	17	18.6	18.6	19.3	20	21.2	21.6
5	12.3	11.4	17.8	16.9	13.8	13.8	15.4	15.4	16	16.7	17.9	18.4
0	9.5	8.7	15.1	14.2	11	11	12.6	12.6	13.2	13.9	15.1	15.6
-5	7.4	6.5	12.9	12	8.8	8.8	10.4	10.4	11	11.7	12.8	13.3
-10	5.7	4.8	11.2	10.3	7.1	7.1	8.7	8.7	9.3	9.9	11	11.5
	<b>WTP (share of cocoa income) for price insurance for a fixed 100 of average production with theta=1 and 12 months in advance</b>											
10	17.4	16.6	23	22.1	19.2	19.2	20.8	20.8	21.6	22.3	23.5	24.1
5	14.5	13.6	20.1	19.2	16.2	16.2	17.8	17.8	18.5	19.3	20.5	21
0	11.9	11	17.5	16.6	13.5	13.5	15.1	15.1	15.9	16.6	17.8	18.3
-5	9.7	8.8	15.2	14.4	11.3	11.3	12.9	12.9	13.6	14.3	15.5	16
-10	7.8	7	13.4	12.5	9.4	9.4	11	11	11.7	12.4	13.5	14

**Table 11: WTP (as share of cocoa income) of Ghanaian cocoa producing households in rural forest region for cocoa price insurance at various levels**

	Share of cocoa in household income											
	0-20%				20-40%				>40%			
	Share of agriculture in household income				Share of agriculture in household income				Share of agriculture in household income			
	<60%		>60%		<60%		>60%		<60%		>60%	
	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor
<b>Strike price relative to future expected price (%)</b>	<b>WTP (share of cocoa income) for price insurance for a fixed 100 of average production with theta=2.4 and 6 months in advance</b>											
10	17.7	16.1	28.2	26.5	20.7	20.7	23.7	23.7	25.1	26.4	28.7	29.6
5	14.4	12.8	24.9	23.2	17.4	17.4	20.4	20.4	21.7	23	25.3	26.2
0	11.7	10.1	22.2	20.5	14.6	14.6	17.6	17.6	18.9	20.2	22.4	23.3
-5	9.5	7.9	20	18.3	12.3	12.3	15.3	15.3	16.5	17.8	19.9	20.8
-10	7.8	6.2	18.3	16.6	10.6	10.5	13.5	13.5	14.6	15.9	18	18.9
	<b>WTP (share of cocoa income) for price insurance for a fixed 100 of average production with theta=2.4 and 12 months in advance</b>											
10	19.7	18.1	30.2	28.6	23.2	23.2	26.3	26.3	27.9	29.4	31.8	32.8
5	16.7	15.1	27.2	25.6	20.2	20.1	23.3	23.2	24.8	26.2	28.6	29.5
0	14.1	12.5	24.6	22.9	17.4	17.4	20.5	20.5	22	23.4	25.7	26.7
-5	11.9	10.3	22.4	20.7	15.1	15.1	18.1	18.1	19.5	20.9	23.2	24.2
-10	10	8.4	20.5	18.8	13.1	13.1	16.1	16.1	17.5	18.8	21.1	22

**Table 12: Comparison of WTP and actual cocoa put option prices in the NYBOT for a fixed 100% of total production and three months in advance**

		Rural forest												
		Share of cocoa in household income												
		0-20%				20-40%				>40%				
		Share of agriculture in household income				Share of agriculture in household income				Share of agriculture in household income				
		<60%		>60%		<60%		>60%		<60%		>60%		
		Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	
Date	Strike price in relation to future price (%)	Actual put option price (% of future price)	WTP with theta=0.2 and 3 months in advance											
05-Jun-02	-6.51	2.58	3	2.8	4.1	3.9	3.2	3.2	3.5	3.5	3.7	3.8	4	4.1
	-3.32	3.8	4.1	4	5.2	5.1	4.4	4.4	4.7	4.7	4.8	4.9	5.2	5.3
	-0.13	5.15	5.5	5.3	6.6	6.4	5.8	5.8	6.1	6.1	6.2	6.3	6.5	6.6
	3.07	7.22	7.2	7	8.3	8.1	7.5	7.5	7.8	7.8	7.9	8	8.3	8.4
	6.26	9.34	9.2	9.1	10.3	10.2	9.5	9.5	9.8	9.8	9.9	10.1	10.3	10.4
Date			WTP with theta=1 and 3 months in advance											
05-Jun-02	-6.51	2.58	4.9	4	10.4	9.5	6.2	6.2	7.8	7.8	8.3	9	10.1	10.5
	-3.32	3.8	6	5.2	11.6	10.7	7.4	7.4	8.9	9	9.5	10.2	11.3	11.7
	-0.13	5.15	7.4	6.6	13	12.1	8.8	8.8	10.3	10.4	10.9	11.6	12.7	13.1
	3.07	7.22	9.1	8.3	14.7	13.8	10.5	10.5	12.1	12.1	12.7	13.3	14.5	14.9
	6.26	9.34	11.2	10.3	16.7	15.8	12.6	12.6	14.1	14.1	14.7	15.4	16.5	17
Date			WTP with theta=2.4 and 3 months in advance											
05-Jun-02	-6.51	2.58	7	5.4	17.4	15.7	9.6	9.5	12.4	12.5	13.5	14.7	16.8	17.7
	-3.32	3.8	8.1	6.6	18.6	16.9	10.8	10.8	13.7	13.7	14.8	16	18.1	19
	-0.13	5.15	9.5	7.9	20	18.3	12.2	12.2	15.1	15.1	16.2	17.4	19.6	20.4
	3.07	7.22	11.3	9.7	21.7	20	14	13.9	16.9	16.9	18	19.3	21.4	22.2
	6.26	9.34	13.3	11.7	23.7	22	16	16	18.9	19	20.1	21.3	23.5	24.4

**Table 13: Comparison of WTP and actual cocoa put option prices in the NYBOT for a fixed 100% of total production and five months in advance**

		Rural forest												
		Share of cocoa in household income												
		0-20%				20-40%				>40%				
		Share of agriculture in household income				Share of agriculture in household income				Share of agriculture in household income				
		<60%		>60%		<60%		>60%		<60%		>60%		
		Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	
Date	Strike price in relation to future price (%)	Actual put option price (% of future price)	WTP with theta=0.2 and 5 months in advance											
05-Jul-00	-8.88	4.1	3.6	3.4	4.7	4.5	3.9	3.8	4.2	4.2	4.3	4.4	4.6	4.7
	-3.19	6.83	5.6	5.4	6.7	6.5	5.9	5.9	6.2	6.2	6.3	6.4	6.7	6.8
	2.51	10.25	8.3	8.2	9.4	9.3	8.6	8.6	8.9	8.9	9.1	9.2	9.4	9.5
	8.2	14.01	11.8	11.6	12.9	12.8	12.1	12.1	12.4	12.4	12.6	12.7	12.9	13
	13.9	18.45	16	15.8	17.1	16.9	16.3	16.3	16.6	16.6	16.7	16.9	17.1	17.2
Date			WTP with theta=1 and 5 months in advance											
05-Jul-00	-8.88	4.1	5.5	4.6	11.1	10.2	6.9	6.9	8.4	8.5	9	9.7	10.8	11.3
	-3.19	6.83	7.5	6.7	13.1	12.2	9	8.9	10.5	10.5	11.1	11.8	12.9	13.4
	2.51	10.25	10.3	9.4	15.8	14.9	11.8	11.7	13.3	13.3	13.9	14.6	15.8	16.2
	8.2	14.01	13.8	12.9	19.3	18.4	15.3	15.3	16.8	16.9	17.5	18.2	19.3	19.8
	13.9	18.45	17.9	17.1	23.5	22.6	19.5	19.5	21	21	21.7	22.4	23.5	24
Date			WTP with theta=2.4 and 5 months in advance											
05-Jul-00	-8.88	4.1	7.6	6	18.1	16.4	10.3	10.3	13.2	13.3	14.4	15.6	17.7	18.6
	-3.19	6.83	9.7	8.1	20.1	18.4	12.4	12.4	15.4	15.4	16.6	17.8	20	20.9
	2.51	10.25	12.4	10.8	22.9	21.2	15.3	15.3	18.3	18.3	19.5	20.8	23	23.9
	8.2	14.01	15.9	14.3	26.4	24.7	18.9	18.9	21.9	21.9	23.1	24.4	26.7	27.6
	13.9	18.45	20.1	18.5	30.6	28.9	23.1	23.1	26.1	26.1	27.4	28.7	30.9	31.9

# Conclusions

1. Method identifies welfare benefit of commodity insurance, not necessarily the actual amount households will pay in any given circumstance.
2. Method gives lower bound (WTP0) and upper bound (WTP) of total benefit to households from commodity insurance
3. Benefit from commodity insurance depends positively on attitudes to risk, and the variability of income, and negatively on the degree of consumption smoothing.
4. Actual put option prices appear to be within the lower and upper bounds of WTP
5. Actual WTP will depend on additional factors such as overall asset level, liquidity constraints, household characteristics.
6. Data requirements for implementation are survey data of commodity producing households, and time series information about uncertain variables that influence their incomes.